



SLAB REPLACEMENT GUIDELINES



STATE OF CALIFORNIA
DEPARTMENT of TRANSPORTATION

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DISCLAIMER

These *Slab Replacement Guidelines* are intended for use by Caltrans' personnel. Engineers and agencies outside of Caltrans may use these guidelines at their own discretion. Caltrans is not responsible for any work performed by non-Caltrans personnel using this guide.

Caltrans intends these guidelines as a resource for all personnel engaged in slab replacements. These guidelines reflect the recommended practice and procedures for design and construction of slab replacements. However, these guidelines are not contract documents. They impose no obligations or requirements on contractors. Resident engineers and other Caltrans personnel who administer Caltrans contracts must never attempt to use these guidelines as a substitute or supplement to the specifications and other contract requirements.

ABSTRACT

These *Slab Replacement Guidelines* were developed by the Office of the Rigid Pavement Materials and Structural Concrete of the California Department of Transportation (Caltrans). They include several key factors that help reduce the time necessary to accomplish slab replacement and improve the quality of the repaired concrete pavement, including the proper selection of the slab removal boundaries and concrete material. Also included are the recommended procedures for saw cutting, slab removal, subgrade and base preparation, concrete placing and curing, sampling and testing procedures, grinding and joint sealing, and opening to traffic criteria. A practical checklist that provides a quick summary of the entire process is also provided in Appendix A.

These slab replacement guidelines have been reviewed and endorsed by the Western States Chapter of the American Concrete Pavement Association.

Questions on these guidelines can be directed to Materials Engineering and Testing Services (METS) Office of Rigid Pavement Materials and Structural Concrete: (916) 227-7281.

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CHAPTER 1 INTRODUCTION



1938 Highway 33
near Pulgas Road



1958
Santa Ana Freeway



Paving in the 1970's

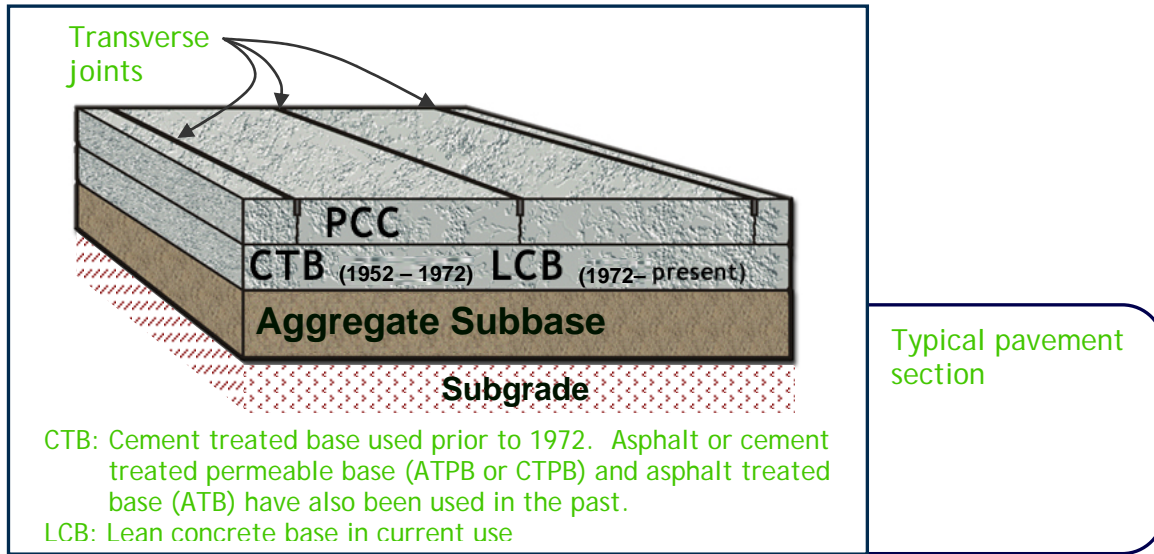
HISTORICAL PREFACE

Most of Caltrans' rigid pavements were built between 1950 and 1970, and they were designed to last 20 years. These pavements have greatly exceeded that design life, and many now need to be rehabilitated or replaced.

Due to the high capacity demand for most of California's urban freeways, Caltrans is often restricted to very short construction windows for pavement rehabilitation. Often the available time for lane closure may be as short as 5 hours and nighttime construction is required, depending on the direction of peak traffic and the day of the week.

Meeting these needs creates difficult challenges for Caltrans' staff and contractors. Many concrete pavements are restored to an acceptable performance level using slab or slab and base repairs. The effectiveness of this repair strategy depends on proper evaluation of the extent and severity of the slab distresses, as well as the condition of the underlying pavement layers.

TYPICAL PAVEMENT SECTION



The most appropriate slab repair must be determined based on the condition of the entire pavement section to be repaired, including the need to remove and replace the existing base. Repair type selection can significantly influence the number of slabs replaced during each shift, as well as the duration and cost of the project. For example, selecting a slab and treated base repair instead of a slab repair when the treated base is in good condition will result in an unnecessary increase in construction time and material costs. Likewise, if only a slab repair is performed when the treated base or underlying subgrade has significant deterioration, the repair may not perform well and it will require additional time and money to improve the repair area to an acceptable level.

It is very challenging to identify the appropriate slab repair properly on a case-by-case basis. **The selection of the proper repair type will save the project time and money by minimizing unexpected or unnecessary repairs.**

Another challenge faced by Caltrans and the contractors is good construction practices. For slab replacements to maintain good performance over time, **the use of proper construction techniques is extremely important.**

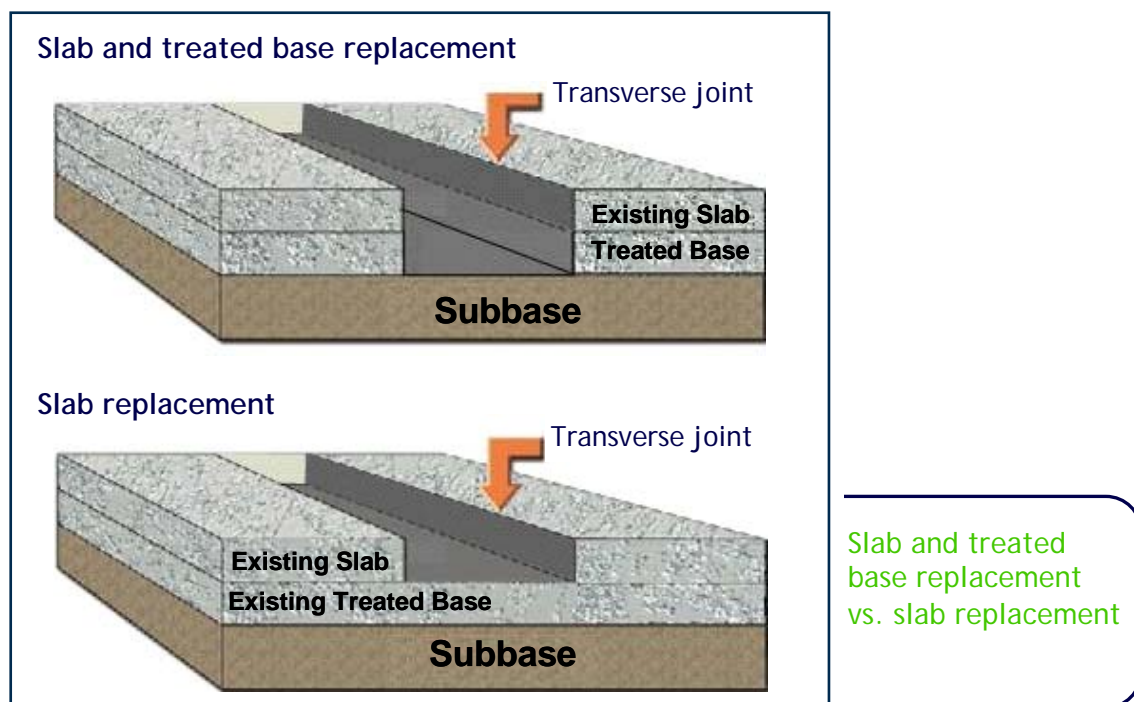
TYPICAL PAVEMENT SECTION

All standard Caltrans rigid pavements constructed prior to 1993 are plain jointed portland cement concrete (PCC). This means that the slabs are not reinforced with steel rebar or welded wire fabric. They are also constructed without any load transfer devices, such as dowels at the transverse joints. However, prior to 1940, jointed plane concrete pavement (JPCP) routinely included dowels at the transverse joints. Older pavement may contain dowel bars as a result of recent retrofitting. Some non-standard design features, such as continuous reinforcement, have been used in test sections, but only in a few isolated locations.

Cement treated base (CTB) became the standard in 1952, although CTB is no longer used under PCC pavements. Lean concrete base (LCB) replaced CTB as the standard base in 1975. In 1983, Caltrans adopted treated permeable base as an allowable base type under JPCP. Asphalt treated base was also used in the past.

In 1993, tied PCC shoulders, tied longitudinal joints, and sealed joints were implemented as a standard for rigid pavements. The Caltrans standard also includes doweled transverse joints as an option. The details of the standard PCC pavement designs are given in Caltrans standard plans (see Appendix E for reference).

SLAB REPLACEMENT



SLAB REPLACEMENT

For the purposes of these guidelines, a slab replacement is defined as a single slab to be replaced in kind. In general, replacement of multiple slabs totaling 30 m or longer is considered lane replacement.

Slab replacement can improve pavement rideability and restore structural integrity while extending service life. Slab replacement can be defined as a slab and treated base or slab repair. Slab and treated base repair consists of removing the concrete pavement, including the treated base, and replacing both layers with rapid strength concrete (RSC) materials, separated by a bond breaker. Slab repair is the removal and replacement of the concrete pavement surface.

Partial-depth repair is the removal and replacement of the concrete pavement surface to not more than $1/3$ of the depth of the slab. Partial-depth repairs are appropriate only for spall repairs at pavement joints. Slab replacement should be used if the spalling extends more than $1/3$ of the depth of the slab or if spalled areas at a joint total 1 m^2 or more.

The treated base and RSC pavement shall be poured separately as long as adequate time is available for the pavement layers to cure properly. In a very short construction window (2-4 hours of cure time), replace the existing treated base with RSC. After placing the RSC for the base layer, a bond breaker is placed on the surface of the replacement base after the base has hardened sufficiently (e.g., hard enough to walk on).

Load transfer should be provided at transverse joints as specified in project plans. Typically, this is accomplished by drilling holes into the existing PCC and securing dowels in the drilled holes with epoxy. Optionally, the dowel bars may be retrofitted.

Repairs and rehabilitation efforts can include jobs as small as a single failed pavement slab panel or as large as the replacement of multiple panels. In general, full panel replacements should be used, unless the slab to be replaced is very long (e.g., 6 m or longer). **The absolute minimum size of a slab replacement should be the full slab width, 3.6 m wide by 2 m long.**

KEYS TO SUCCESS

KEYS TO SUCCESS

Several key factors help reduce the time necessary to accomplish slab replacement and improve the quality of the repaired concrete pavement. Many aspects of a project should be considered, including the following:

DESIGN

- Thorough review of project – prior to advertising, the project engineer should review the project to verify pavement condition
- Proper selection of slab removal boundaries on the plans
- Concrete material selection and approval
- Replacing existing tie bars
- Grinding and joint sealing
- Opening-to-traffic criteria

INSPECTION

- Conformance with the contract specifications and plans
- Proper selection of slab removal in the field or based on initial survey
- Procedure for saw cutting and concrete removal
- Preparation and compaction of subbase material
- Dowel installation techniques
- Concrete placing and curing provisions
- Sampling and testing procedures
- Grinding and joint sealing
- Opening-to-traffic criteria

CONTRACTOR

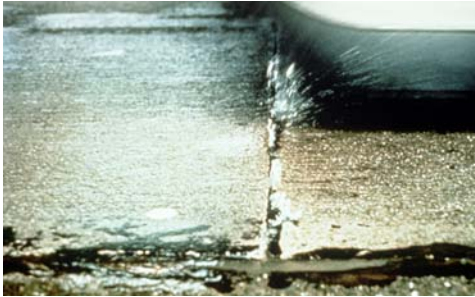
- Concrete material selection and approval
- Procedure for saw cutting and concrete removal
- Preparation and compaction of subbase material
- Dowel installation techniques
- Concrete placing and curing
- Grinding and joint sealing
- Opening-to-traffic criteria

NOTE TO DESIGNERS:

During short construction windows, the contractor will need to replace the slab and allow it to cure to reach strength. Do not specify the drill-and-bond method of dowel placement if the construction window is less than 8 hours. Dowels may be retrofitted on projects with a short construction window. Typically, contractors can place 20 to 26 replacement slabs within an 8-hour construction window.

Any use of dowel bars at repair joints should be well documented to avoid costly change orders if the project is later selected for dowel bar retrofitting.

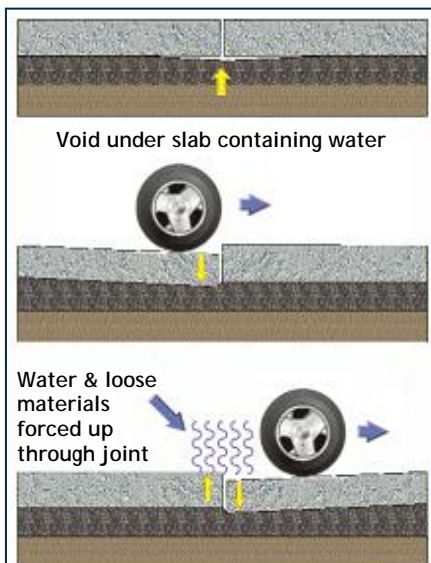
CHAPTER 2 PROJECT EVALUATION



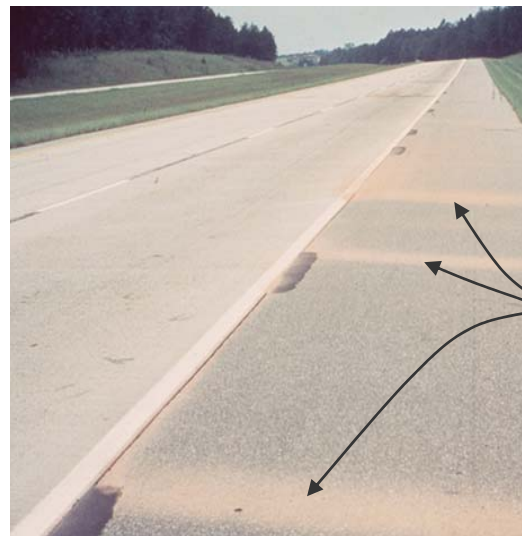
Pumping in action



Loss of shoulder material due to pumping



Pumping schematic



Pumping of loose pavement fines onto the highway shoulder

SLAB REPLACEMENT CONSIDERATION

In planning a slab replacement project, it is important to consider the pavement age, pavement condition, and traffic levels. Not all projects are good candidates for slab replacements (see p.18). For example, slab replacement is not an effective rehabilitation strategy for structural deficiency and for problems in concrete material, base, or subgrade. Such problems require a structural overlay or reconstruction. A relatively new pavement (<10 years old) exhibiting extensive cracking and a pavement that is rapidly developing new cracks are some of the signs of structural deficiency. Cost is also a factor, and slab replacement may not be economical for badly cracked pavements (e.g., 3rd stage cracking in more than 10% of slabs).

PAVEMENT CONDITION SURVEYS

Caltrans conducts pavement condition surveys annually. The survey data can be obtained from the District Maintenance Engineer. Also the Office of Pavement Rehabilitation at Translab can be contacted to obtain falling weight deflectometer (FWD) readings or drill cores. The FWD data can be used to determine load transfer efficiency (LTE, see page 13).

The data from annual surveys can be used to determine the extent of damage to slabs and ride quality. The results of the survey should be used as a trigger for slab replacement. Some of the key distresses are defined in this chapter.

PUMPING

PUMPING

Pumping is the ejection of loose materials carried by water from under the pavement through cracks and joints when impacted by traffic.

Causes:

Four conditions must coexist for pumping to occur: frequent heavy axle loads, poor joint LTE, erodible base and/or wet-fine subgrade, and the presence of excess water under the pavement.

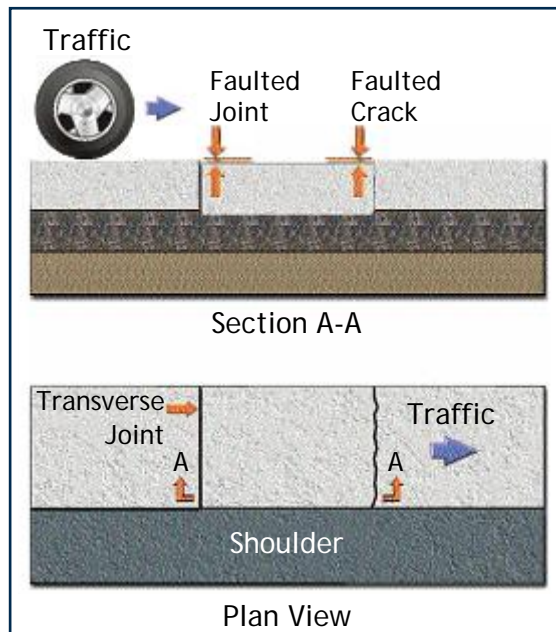
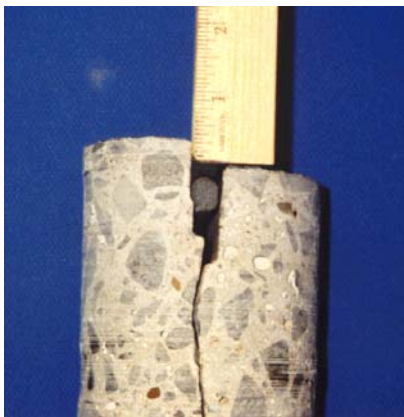
- Sealing the longitudinal and transverse joints reduces water infiltration and keeps the incompressibles out.
- Pumping becomes a serious problem when the displaced material results in loss of support, especially at the corner, where larger deflections and stresses may result in corner breaks.

- Pumping can also cause transverse cracking, spalling of the joints, and faulting, and it may contribute to longitudinal cracking.
- Fines from pumping and erosion of the base and subgrade can be seen along shoulders, especially after a rainstorm, as shown on page 5.

Sunken shoulders and loss of fine material are an indication of potential problems. If pumping has not caused significant deterioration, a possible maintenance remedy is to insert grout or polyurethane foam into the voids to reduce slab movement and deter deterioration. Grout pumping is typically used by maintenance personnel as a temporary measure and should not be used on construction contracts. However, grouting may be required for innovative pavement construction, such as precast PCC slab construction. Any use of grouting in such applications should be in compliance with the Caltrans specifications for the application.

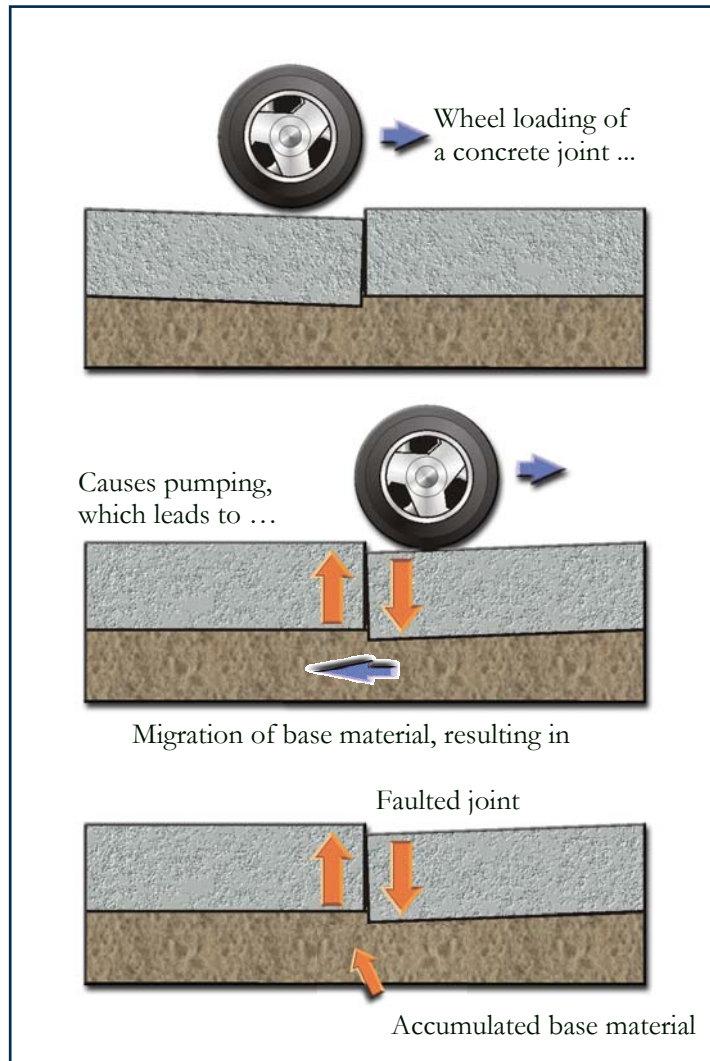


Faulted joints



Faulting schematic

FAULTING



Faulting
mechanism

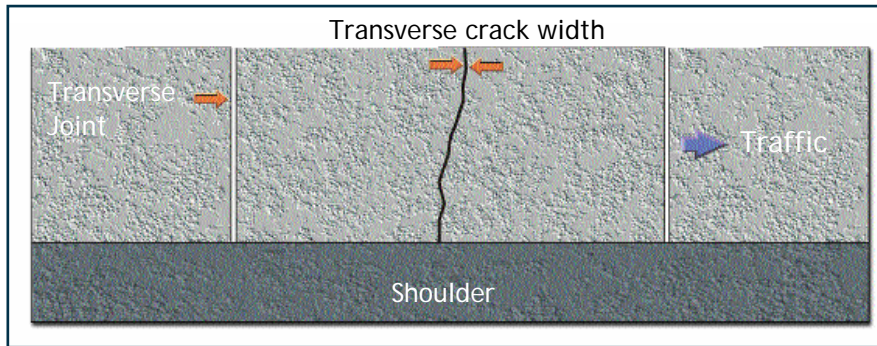
FAULTING

Faulting is a difference in elevation between slabs at joints or cracks.

Causes:

- Faulting is caused by a combination of heavy axle loads, poor joint or crack load transfer efficiency, erodible material in the layers beneath the concrete slab, and the presence of free water beneath the pavement.
- Temperature and moisture gradients can curl the slab corners upward, resulting in increased potential for pumping and faulting.
- The hydraulic action drives the fines beneath the pavement slab in the direction opposite the direction of traffic. Over time, this results in a buildup of fines under the approach side of the joint. The amount of buildup coincides with the amount of faulting (step-off) on the pavement surface.

TRANSVERSE CRACKS



Transverse crack schematic



Transverse cracking

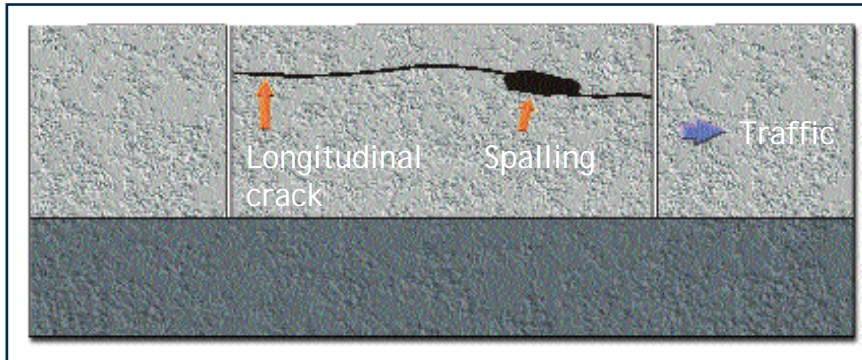
TRANSVERSE CRACKS

Transverse cracks cross the slab in a direction nearly perpendicular to the pavement centerline and the direction of traffic.

Causes:

- Typically, new concrete slabs crack when tensile stresses within the slab exceed the slab's tensile strength. Early-age cracking may occur from a combination of restraining forces due to temperature changes, shrinkage, thermal curling, and moisture warping, combined with traffic loads imposed on the concrete before it has gained sufficient strength. This type of cracking can be controlled by sawing the pavement to create weakened-plane joints at appropriate intervals. Uncontrolled (volunteer) transverse cracks typically result from improper joint sawing (shallow sawed depth or late sawing).
- Transverse cracks that occur in the years following construction are primarily the result of fatigue of the concrete slab caused by repeated heavy axle loads and temperature curling. The cracks develop when the accumulated fatigue damage approaches or exceeds the fatigue life of the PCC.
- Shorter panel lengths used today reduce the potential for fatigue-related transverse cracking. Excessive panel lengths (e.g., 6 m) lead to excessive curling and warping stresses, which often lead to premature mid-panel cracking. Refer to the Caltrans Standard Plans for the current transverse joint spacing.

LONGITUDINAL CRACKS



Longitudinal crack schematic



Longitudinal cracking

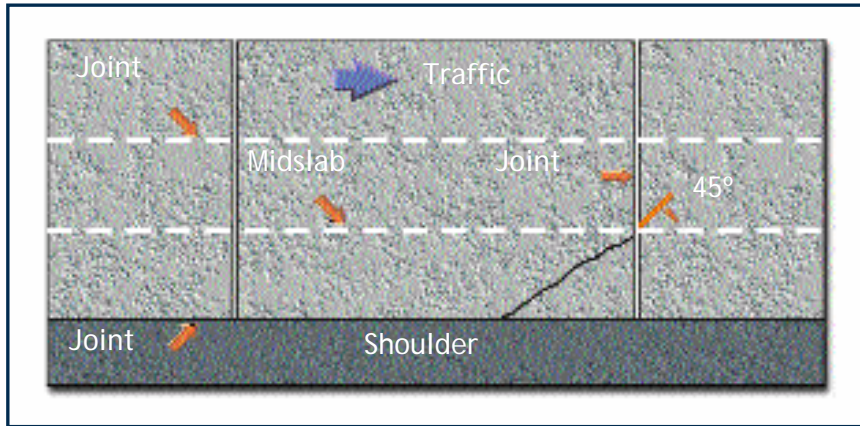
LONGITUDINAL CRACKS

Longitudinal cracks run parallel to the edge of the slab and in the direction of traffic.

Causes:

- Early longitudinal cracks can be caused by inadequate saw-cut depth or late sawing of longitudinal joints. Unless the joints form properly, the risk of longitudinal cracking is very high due to the restraining forces from shrinkage or temperature changes and stresses from slab curling and warping. Early cracking can also result from opening the pavement to traffic before the concrete has achieved adequate strength.
- Longitudinal cracking occurring late in the pavement's life may be caused by a combination of upward slab curling (temperature and moisture gradients) and heavy repeated axle loadings.

CORNER BREAKS



Corner breaks schematic



Corner breaks

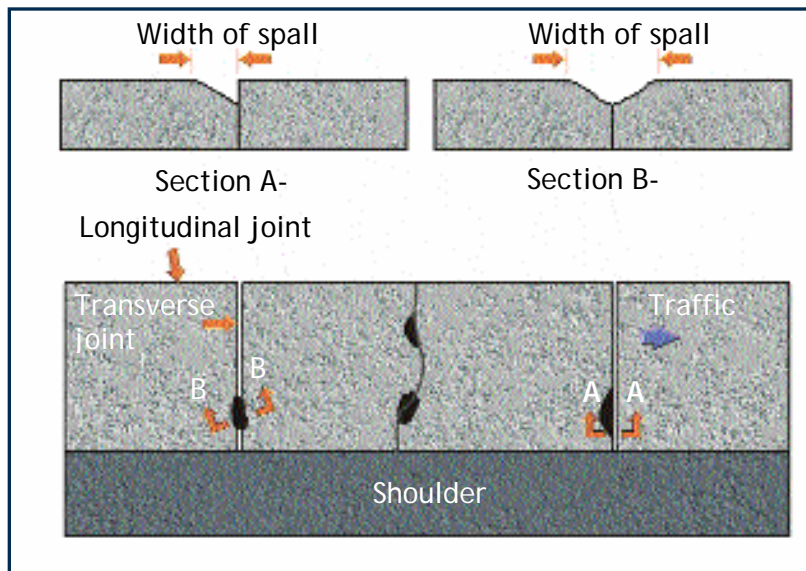
CORNER BREAKS

A corner break is a crack that intersects a transverse joint and the pavement edge at a distance of about 2 m or less on each side from the corner of the slab and is over 0.5 m long.

Causes:

- Corner breaks are caused by heavy repeated axle loadings on upward curled slab corners due to temperature and moisture gradients, and lack of adequate load transfer.
- Loss of slab support (voids) due to pumping.

JOINT SPALLING



Joint spalling schematic



High-severity joint spalling

JOINT SPALLING

Joint spalling can occur at both the transverse and longitudinal joints. Medium- and high-severity spalling require full-depth repairs, unless the deterioration is limited to the upper 1/3 of the slab, in which case partial-depth spall repairs may be feasible. On a typical joint, coring can help determine the general extent of the subsurface deterioration beneath the joint.

Causes:

- Spalling is caused by the build-up of incompressible materials in the joints, which causes large stresses when the slab expands. As the face of

the joint or crack spalls, it deposits more incompressibles, causing further deterioration.

- Weak areas caused by inadequate consolidation of the concrete near joints provide a starting point for spalling to occur.
- Some joint spalling may be the result of concrete durability distresses, such as reactive aggregate.

While joint spalling is not the focus of this document, it may be appropriate to address medium- and high-severity spalls during slab replacements.

STAGES OF SLAB DETERIORATION



First-stage cracking



Third-stage cracking

ADDITIONAL PAVEMENT DISTRESS FACTORS

Other factors that may contribute to joint deterioration are:

- Poor design or construction practices that create locally weak areas within the slab
- Poor joint sealant maintenance
- Improper installation of joint sealant

STAGES OF SLAB DETERIORATION

There are three distinct stages of slab deterioration, according to the Caltrans Highway Design Manual:

- **First-stage cracking:** Non-intersecting transverse, longitudinal, or diagonal cracks in a slab that divide the slab into two or three large pieces. This does not include corner breaks.

- **Third-stage cracking:** Cracking of the slab into three or more pieces with interconnected cracks developing between cracks or joints.

Note:

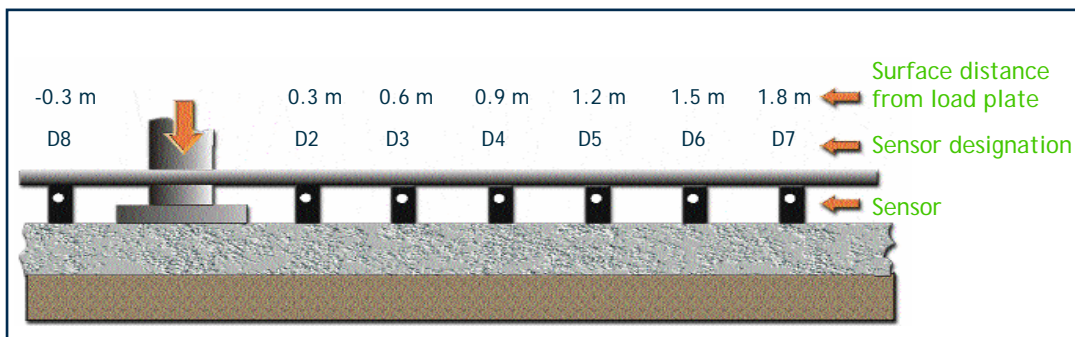
Stage 1 and Stage 3 cracking cannot coexist within the same slab; however, corner breaks may coexist with both Stage 1 and Stage 3 cracking.

Stage 2 cracking is not considered for this type of evaluation.

NONDESTRUCTIVE TESTING



Falling Weight Deflectometer (FWD)



Typical FWD load plate & sensor spacing

TYPICAL PAVEMENT INSPECTION TECHNIQUES

Various techniques can be used to assess pavement condition. Common approaches include conducting falling weight deflectometer (FWD) testing, drainage survey, and coring.

NONDESTRUCTIVE DEFLECTION TESTING

A number of nondestructive pavement testing devices are currently in use, but the FWD is the most widely accepted in the pavement engineering field. The FWD consists of an impulse loading device that applies a load to the pavement surface by dropping a weight onto a spring buffer connected to a load plate of known dimensions. By varying the falling weight mass and the drop height, the magnitude of the applied load can be changed. The resulting pavement deflection is measured by seismic deflection transducers. One transducer is located at the center of the loading plate, and the remaining sensors are commonly spaced at 300-mm intervals away from the load plate.

By collecting deflection measurements at several offsets from the load plate, the deflection profile (or basin) can be determined. In general, weak pavements have high deflections that are confined to a small area, and stiff (strong) pavements have small deflections that are distributed over a much wider area. By analyzing the magnitude and shape of the deflection basin at the slab center, the strength of the in-place pavement and subgrade materials can be estimated. In addition, the load transfer efficiency at joints and cracks, as well as the presence of voids at corners, can be evaluated quickly.

Nondestructive testing (NDT) provides information about a pavement's overall structural capacity, and it can pinpoint areas of weakness. NDT alone cannot, however, completely identify which pavement component is responsible for weaknesses, or whether moisture-related problems exist. A pavement drainage survey and limited coring may also be required.

PAVEMENT DRAINAGE ANALYSIS



Pumping of
pavement
materials

Fines shown on shoulder of base
material pumped to surface indicates
possible voids under pavement



Properly
functioning
pavement
edge drain

PAVEMENT DRAINAGE ANALYSIS

Excess water in the pavement structure is often a significant contributor to poor pavement performance, even in dry climates. Moisture-related or moisture-accelerated rigid pavement distresses include pumping, faulting, and cracking, as well as PCC material problems such as alkali-silica reactivity (ASR). Water can enter the pavement structure from the top (through joints and cracks on the pavement surface), laterally (through the natural soils), and from the bottom (capillary action from the underlying water table).

The drainage survey should provide answers to the following questions:

- Are the joint sealants in satisfactory condition?
- Are the ditchlines properly graded and clear of debris or vegetation?
- Is there standing water or signs of standing water in the ditchlines?
- After a rainstorm, is there water standing in the joints or cracks?

- Is there evidence of pumping, or do small settlements exist in the AC shoulders at joints (blow-holes)?
- Is there water standing at the outer edge of the shoulder, or is there evidence that water may pond on the shoulder, as shown by stains or fine material accumulation (see photos on page 15)?

If subsurface drainage is present:

- Are the outlets clear of debris and set at the proper elevation above the ditch line?

Identifying drainage problems is important for ensuring good long-term performance of rehabilitated rigid pavements. Certain problems, such as clogged drainage fabric, are not always correctable, and the presence of significant drainage problems may limit the feasibility of pavement rehabilitation through restoration methods.

PAVEMENT DRAINAGE ANALYSIS (CONTINUED)



Erosion & settlement of the shoulder material



Distressed PCC patch due to construction of the patch wider than the paving lane



Edge form placed after removing 0.3 m of deteriorated shoulder

There may be other more cost-effective means, other than slab replacement, to address problems that are either caused or aggravated by poor drainage.

- Pumping and faulting may be addressed effectively through the addition of retrofitted dowel bars and diamond grinding.
- Pavement drains may be repaired cost-effectively, depending on the drainage rehabilitation required. Use engineering judgment during the pavement drainage survey.

If the drainage system collapses during pavement removal:

- Place a form at the edge of the concrete pavement lane to allow a full slab width replacement to occur.

- Replace the edgedrain, in kind, and backfill with AC.
- Never construct a replacement slab wider than the paving lane.

NOTE TO DESIGNERS:

When the shoulder is severely distressed or settled, be sure to include detail and funding to remove 0.3 m of shoulder and place a form for the edge of pavement. The form will also be used to set a smooth grade. The gap must be backfilled with AC to match the adjacent shoulder.

CORING



Core drilling



Coring to investigate the causes of pavement distress

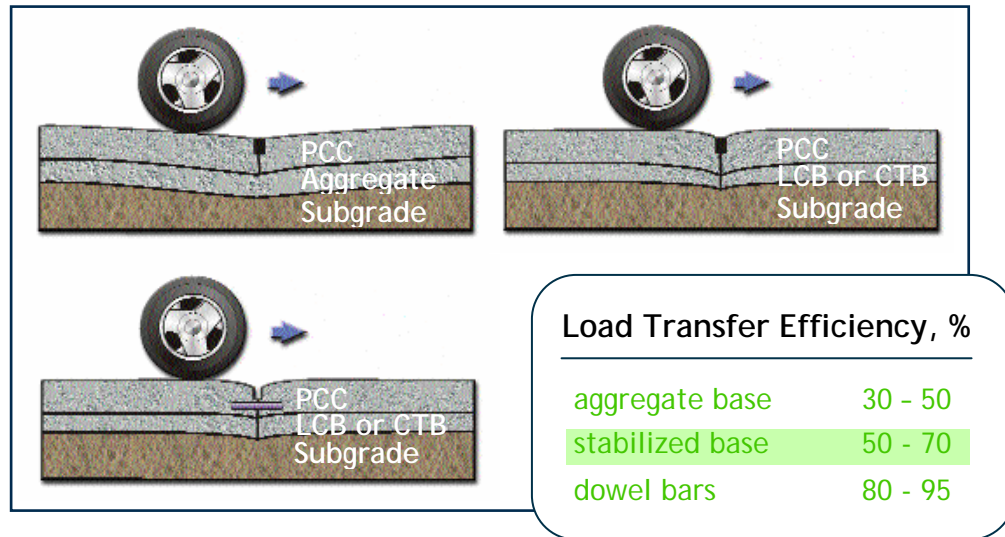


Core with backer rod and aggregate interlock

CORING

Limited coring may be needed to determine the extent and severity of distress beneath the pavement surface. Coring should only be used on a limited basis because it is time-consuming and causes additional lane closures. Work with your District Materials Engineer (DME) to obtain the cores. Cores will give you information about the condition and thickness of the existing concrete pavement, treated base layer, and subbase, which may indicate whether the base will need to be removed and replaced with the slab.

LOAD TRANSFER



LOAD TRANSFER

Caltrans' concrete pavements typically rely on aggregate interlock and the treated base course for load transfer. The coarse aggregate in the PCC at the slab joint faces interlock to help transfer wheel loads from one slab to the next. The bottom figure on the opposite page shows a good example of aggregate interlock. Over time, the exposed surface of coarse aggregate may become worn due to repeated loadings and weathering, resulting in a smoother texture and a lower load transfer capacity. This reduction in load transfer capacity leads to increased joint movements and an increase in pavement distresses.

Aggregate interlock may provide adequate load transfer throughout the design life during warm weather, but the load transfer can vary considerably throughout the year. In fact, Caltrans has observed significant differences in the load transfer between early morning and afternoon. As the joint opens due to temperature variations, aggregate interlock is lost and load transfer is greatly reduced. Load transfer also decreases over time due to friction abrasion of the joint face.

Depending on the size and type of aggregate, an opening as small as 0.25 mm can cause a significant reduction of the LTE. Stabilized base and dowel bars improve LTE and reduce the impact of temperature and abrasion. FWD testing is important to determine the LTE of joints and cracks within the project, especially during cooler weather (<25°C).

Typically, pavement sections with deflection load transfer values less than 70 percent do not perform adequately. Those pavements may show signs of pumping, faulting, corner breaks, and spalling and may require slab replacement. Joints and cracks with LTE greater than 70 percent may provide an acceptable serviceability level for many years. Joints or cracks with poor LTE and no other associated distresses may benefit from dowel bar retrofit, which can be a more cost-effective repair.

LOAD TRANSFER DESIGN

Dowel bars are highly effective in providing load transfer across joints or cracks. The recommended dowel bars are 460 mm long and 38 mm in diameter. New construction requires 12 bars, spaced 300 mm on center along the transverse joint. Slab replacements require 3 dowel bars spaced 300 mm on center in each wheel track for non-truck lanes and 4 bars spaced 300 mm on center in each wheel track for truck lanes. Since lane striping is subject to change, Caltrans has allowed for nine bars to be spaced evenly across the transverse joint; however, the design that concentrates the bars in the wheel tracks with a bar spacing of 300 mm is highly recommended. If the location of lane striping is uncertain, use 12 bars at 300 mm spacing. For new transverse joints located 2.3 m or less from the existing slab transverse joint, tie bars may be installed at 600 mm on center along the new construction joint in lieu of the dowel bars.

SLAB REPLACEMENT CRITERIA

SLAB REPLACEMENT CRITERIA

In determining the need for slab replacements, consideration must be given to the extent and type of distress within a project. **The table at the bottom of this page lists good candidates for slab replacement.**

As noted under *Slab Replacement Consideration* (p.5), the following pavements may not be good candidates for slab replacements:

- Structurally deficient pavements:
 - Extensive cracking in relatively new pavements (<10 years old)
 - More than 10% 3rd stage cracking
 - Rapid development of new cracks.
- Pavements with moderate to severe material problem (e.g., ASR)
- Pavements with base or subgrade problems, as indicated by settlements.

For the conditions listed above, slab replacement is not an effective rehabilitation strategy. On such pavements, continued deterioration of the original pavement is likely to result in rapid redevelopment of cracking, spalling, and roughness. A better long-term repair solution for such pavements may be an unbonded concrete overlay, reconstruction, or crack

and seat and overlay with AC. In all cases, the cost of slab replacement should be compared against the cost of an overlay or reconstruction to ensure that slab replacement is cost effective for the project being considered.

In evaluating the appropriate rehabilitation strategy, consideration should also be given to the deterioration that may have taken place since the distress survey, especially if significant time has passed (e.g., more than 1 year).

Cracks in rigid pavements are not necessarily an immediate serviceability concern. Depending on traffic level and climate, cracked slabs can provide acceptable serviceability for an extended period of time. However, on roadways that carry high volumes of heavy truck traffic (e.g., $TI > 10$), cracks can rapidly deteriorate to a severity level that requires slab replacement. Traffic levels play an important role in the rate of deterioration, and they merit consideration in selecting distresses to be repaired with slab replacements. While the cracks are still low-severity, retrofitted dowel bars can be effective in preventing further deterioration.

All slabs with 2 or more corner breaks.

All slabs with third-stage cracking (see page 12).

Slabs with segments that are moving relative to each other.

Slabs with longitudinal or transverse cracks more than 13 mm wide. Depending on traffic level, lower-severity cracks may also need to be included to ensure that additional repairs will not be needed within the target rehabilitation design life.

Cracks with spalling and loss of concrete greater than 150 mm from the crack centerline and loss of aggregate interlock.

Slabs damaged by lack of support due to settlement, base failure, or excessive curling.

Guidelines for identifying slab replacement repair areas

TRANSVERSE JOINT ORIENTATION

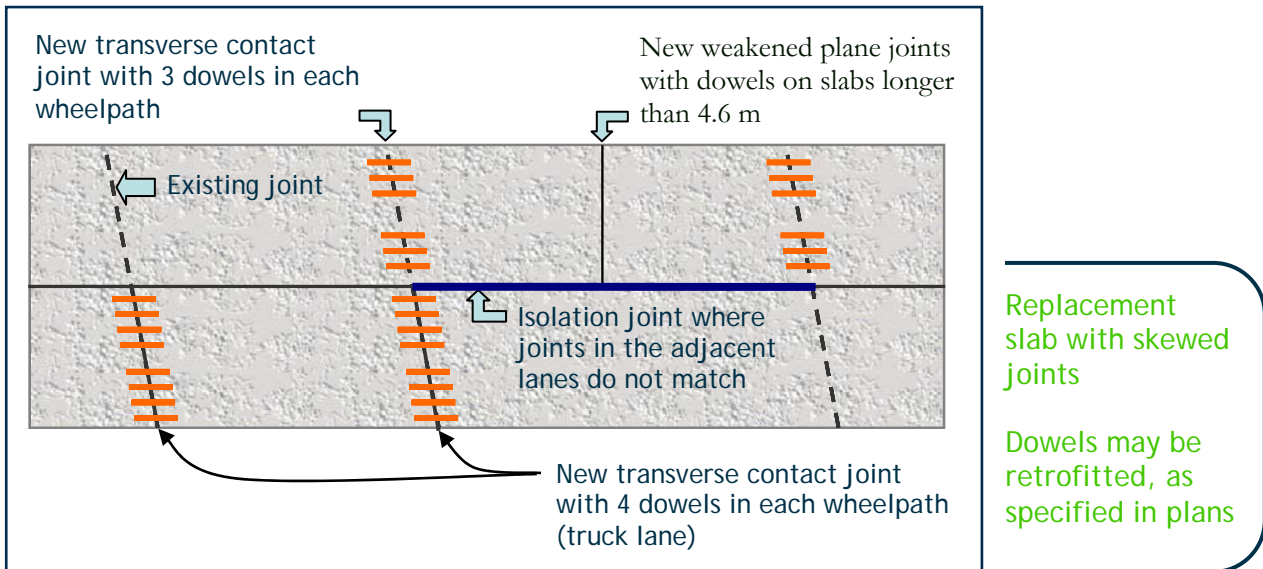
TRANSVERSE JOINT ORIENTATION

Transverse joints should typically match the spacing and skew of the existing pavement. Match existing skewed joints, especially on single slab replacements.

Where the joints in adjacent lanes do not match, the longitudinal joints require an expansion joint filler material to isolate the new concrete from the existing. This isolation joint will prevent the intermediate joint in the replacement slab from initiating cracking in the adjacent lane.

The illustration below is for instructional purposes only, where dowels are placed either by drill-and-bond method or retrofitted.

Special Case Illustration: use when placing dowels



LARGE AREA REMOVAL AND REPLACEMENT

LARGE AREA REMOVAL AND REPLACEMENT

A time-consuming and important step in the slab replacement process is preparing the transverse contact joints, which may include sawing the perimeter, drilling and grouting dowel holes, placing the dowels and expansion material, and sealing the joint. It is cheaper and faster to combine two closely located replacement areas into one large area, because this reduces the number of transverse contact joints to prepare. Replace a single slab between two slabs that are being replaced. A continuous pour typically

results in a long-term improvement of load transfer and smoother pavement.

If two replacement slabs are closer than the distances shown in the table, it is probably more cost-effective to combine them into one large slab. However, long panels have a tendency to crack at mid-slab; therefore, repairs longer than 4.6 m should be constructed with an intermediate weakened plane joint to prevent replacement slab cracking.

SLAB THICKNESS, mm	MINIMUM DISTANCE BETWEEN REPAIRS, m
180	4.0
205	3.4
230	3.0
255	2.8
280	2.4
305	2.4
380	1.8

Criteria for combining adjacent repairs for 3.6-m slab widths

Note: When two repairs are closer than the distances shown in the table, they should be combined into one large repair.



An example of two closely located repairs with existing slabs in between. A more cost-effective option may be to place one continuous repair with weakened plane joints.

DESIGN DETAILS AND ADJACENT-SLAB REPLACEMENTS

DESIGN DETAILS

The applicability of various design details depend on the desired performance life of the replacement slabs. Design features such as dowel bars, tie bars, and joint seal improve the performance life of replacement slabs. However, if the replacement slab only needs to last a short time (e.g., 1 yr) until the pavement can be reconstructed or overlaid, premium features are not needed. The recommended design details for different target performance lives are summarized in the table below, along with the criteria for replacing a slab.

ADJACENT SLAB REPLACEMENTS

On multiple-lane highways, deterioration of the slabs may occur in only one lane or across two or more lanes. If distress exists in only one lane, it is not necessary to repair the other lanes. When two or more longitudinally adjacent slabs contain distresses, generally one slab is repaired at a time so that traffic flow can be maintained. In such cases, an expansion

material, serving as an isolation joint, must be placed to separate the replacement slabs in the second lane from those in the first lane. The isolation joints prevent propagation of any movements from one slab to the next across the isolation joint, thus protecting the slabs from the effects of deleterious movements of the adjacent slab. The isolation joint will prevent damage to the newly placed replacement slab during the removal of the distressed concrete in the second lane. Once the deteriorated second lane slabs are removed, the expansion material between the two replacement slabs should be removed, provided the transverse joints in the adjacent lanes match.

FIELD DATA COLLECTION

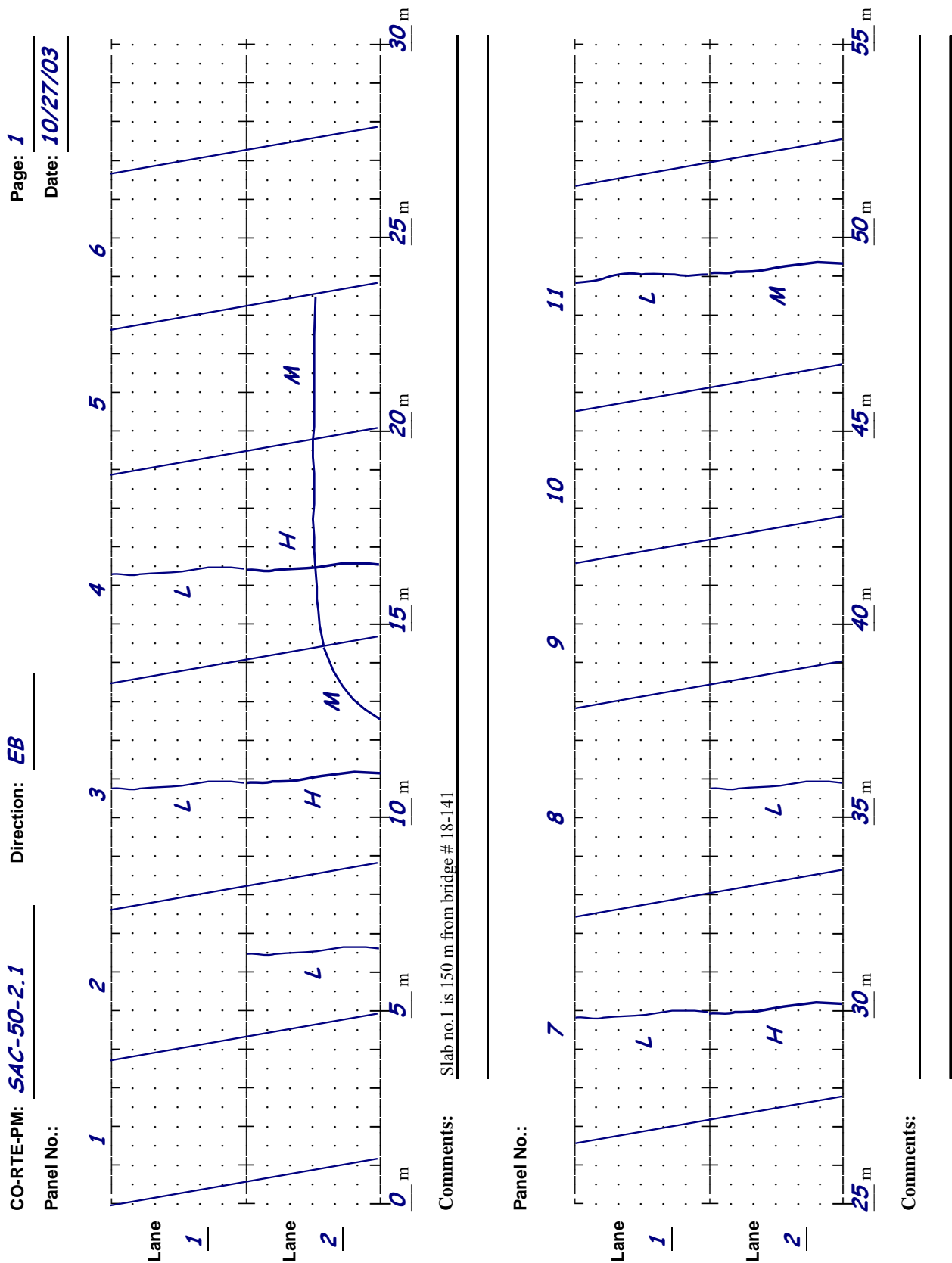
Example field inspection and summary forms are shown in the following pages. Blank sheets of these forms are given in appendix A, starting at page a.7.

Pavement Condition	Emergency ≤ 1 year	Short term 1-5 years	Long term 5-10 years
Replace Slab?			
Slabs with 2 or more corner breaks	no	no	yes
Cracks making slabs < 2 m wide	no	yes	yes
Slabs with 3 rd stage cracks	no	yes	yes
Spalled and faulted cracks	yes	yes	yes
Loss of support and settlement	no	no	yes
Pumped fines on shoulder	no	no	yes
Design Feature	Emergency ≤ 1 year	Short term 1-5 years	Long term 5-10 years
Use the design feature?			
Dowel bars*	no	no	yes
Joint sealing	no	no	yes
Tie bars, if existing	no	no	yes
Large area replacement	no	no	yes
Diamond grinding	yes	yes	yes

Slab replacement selection criteria and recommended design features

*If the construction window is less than 8 hours, do not install dowel bars by drill and bond method. Consider dowel bar retrofit

EXAMPLE DISTRESS MAP (SEE APPENDIX A)



EXAMPLE FIELD DATA SUMMARY FORM (SEE APPENDIX A)

CO-RTE-PM: SAC-50-2.1

Date: 10/27/2003

Direction: EB

Lane	Panel No.	Cracking		Faulting mm	Pumping (y/n)	Other Distress	Photo no.	Comment
		Type	Severity					
1	3	TC	L	2	n		2	
1	4	TC	L	2	n			
1	7	TC	L	2	n			
1	11	TC	L	2	n			
2	2	TC	L	2	n			
2	3	TC	H	6	n		1	
		CB	M	4	n			
2	4	SS	H	5	y		3	
2	5	LC	M	6	n		4	
2	7	TC	H	6	n		5	
2	8	TC	L	2	n			
2	11	TC	M	3	n		6	

Cracking type:

TC = transverse; LC = longitudinal; CB = corner break

SS = Stage 3 (shattered slab with intersecting cracks)

Other distress type: ASR = Alkali-silica reactivity; R = Wheelpath rutting

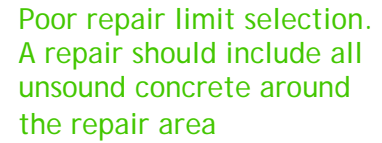
Distress severity: transverse cracking

	Low (L)	Medium (M)	High (H)
Crack width (mm)	< 3 mm	≥ 3 mm; < 6 mm	≥ 6 mm
Faulting (mm)	< 2 mm	≥ 2 mm; < 6 mm	≥ 6 mm
Spall width (mm)	none	< 75 mm	≥ 75 mm

Distress severity: longitudinal cracking and corner breaks

	Low (L)	Medium (M)	High (H)
Crack width (mm)	< 3 mm	≥ 3 mm; < 13 mm	≥ 13 mm
Faulting (mm)	< 2 mm	≥ 2 mm; < 13 mm	≥ 13 mm
Spall width (mm)	none	< 75 mm	≥ 75 mm

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Sample slab replacement map (see appendix A)

All slab replacement areas should be sawed as one linear cut and extend the full width of one slab.

NOTES